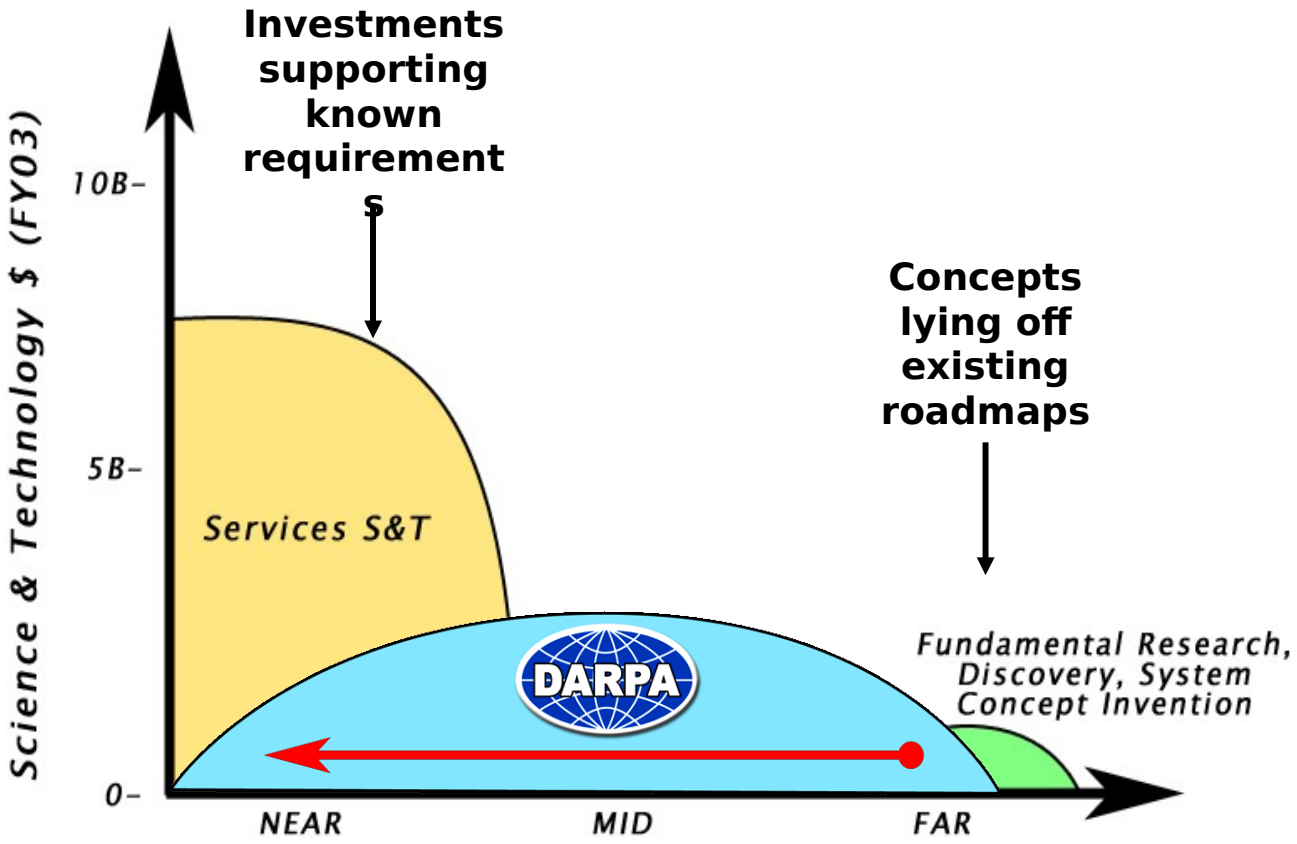
DARPA's S&T Program

NDIA 6th Annual Science & Engineering Technology Conference

Charlestown, SC April 21, 2005

Dr. Robert Leheny
Deputy Director

DARPA's Role in Defense Science & Technology



DARPA sponsoring revolutionary, high-payoff research that <u>bridges the gap</u> between fundamental discoveries and their military use

Maintaining the technological superiority of the U.S. military while preventing technological surprise from harming our national security

DARPA Organization

Director, Tony Tether
Deputy Director, Bob Leheny

Information Exploitation
Ted Bially
Bob Tenney/Bob Popp

- **Sensors**
- **Exploitation Systems**
- **Command & Control**

Tactical Technology
Art Morrish
Gary Graham/Stephen Welby

- **Air/Space/Land Platforms**
- **Unmanned Systems**
- **Space Operations**
- **Laser Systems**
- **Future Combat Systems**
- **Planning / Logistics**

Special Projects
Amy Alving
Joe Guerci

- **Chem/Bio Def Systems**
- **Counter Underground Facilities**
- **Space Sensors/Structures**
- **Navigation/Sensors/ Signal Processing**

Advanced Technology
Dave Honey
Larry Stotts

- **Assured C3ISR**
- **Maritime**
- **Early Entry/Special Forces**

Joint Unmanned Combat Air Systems
Mike Francis

- **Common Systems & Technologies**
- **X-45 System**
- **X-47 System**

Defense Sciences
Steven Wax
Brett Giroir

- **Bio Warfare Defense Technologies**
- **Biology**
- **Materials & Devices**
- **Mathematics**

Information Processing Technology
Ron Brachman
Barbara Yoon

- **Cognitive Systems**
- **Computational - Perception**
- **Representation & Reasoning**
- **Learning**
- **Natural Communication**

MicrosystemsTechnology
John Zolper
Dean Collins

- **Electronics**
- **Optoelectronics**
- **MEMS**
- **Combined Microsystems**

DARPA's Strategic Thrusts

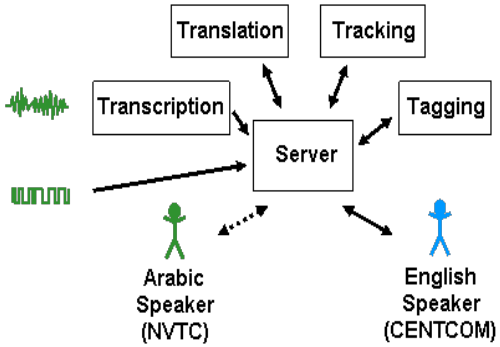
Investments Today for Future Capabilities

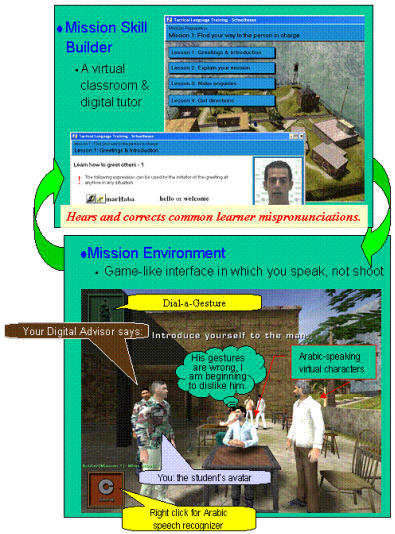
- Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets
- Location and Characterization of Underground Structures
- Force Multipliers for Urban Area Operations
- Networked Manned & Unmanned Systems
- Robust, Secure Self-Forming Tactical Networks
- Cognitive Systems
- Bio Revolution

Technology Support to Deployed Forces

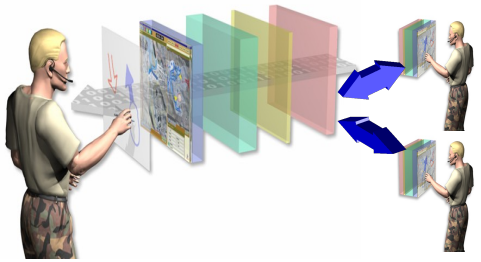
OEF/OIF DARPA Rapid Reaction Program

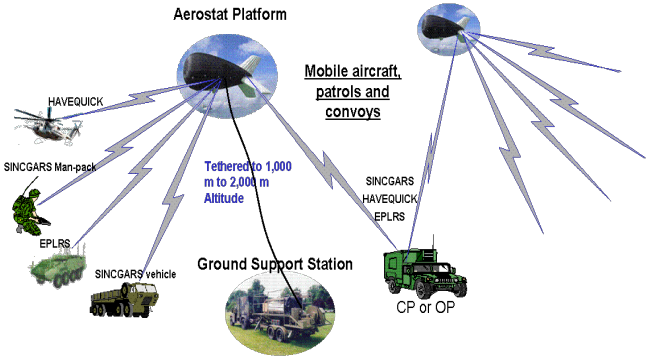
es




Mission Skill Builder
A virtual classroom & digital tutor
Hears and corrects common learner mispronunciations.
Mission Environment
Game-like interface in which you speak, not shoot
Dial-a-Gesture
Your Digital Advisor says:
His gestures are wrong, I am beginning to dislike him
Arabic-speaking virtual characters
You: the student's avatar
Right click for Arabic speech recognizer

1. Water Pen
2. Translingual Information Detection, Extraction, & Summarization (TIDES)
3. Phraselator
4. CPOF
5. Boomerang
6. Marine Airborne Retransmission System (MARTS)
7. Enhanced Combat Training



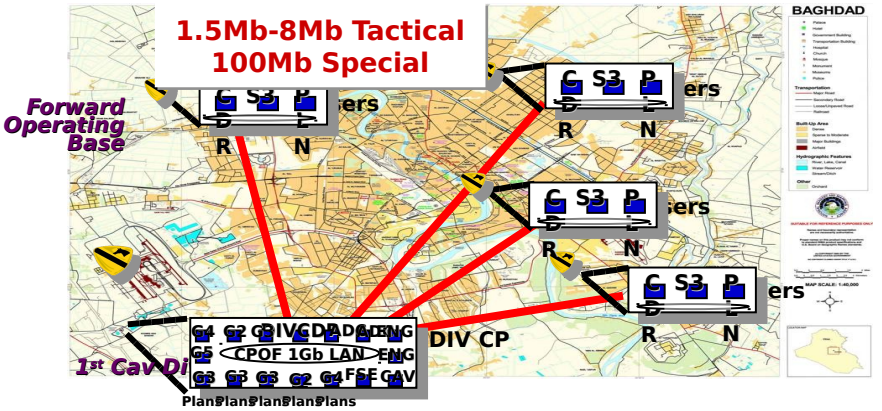


Quick Reaction Support for Operation Enduring Freedom

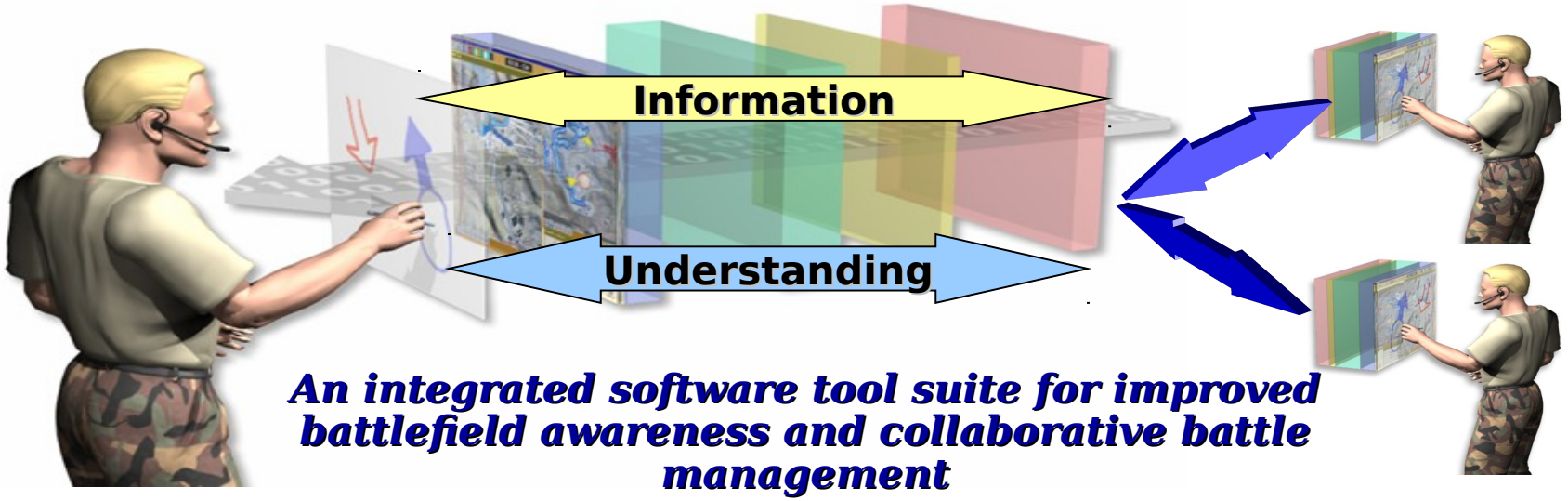
- **Boomerang**
- **Counter-RPG**
- **Marine Airborne Re-Transmission System**
- **Command Post of the Future**
- **Advanced Sensing Technology**
- **Enhanced TIDES Reconstruction Report (eTIRR)**
- **Counter-IED Methods**

DARPA TIDES Iraq Reconstruction

No. 202, 21 May, 2004



Command Post of the Future

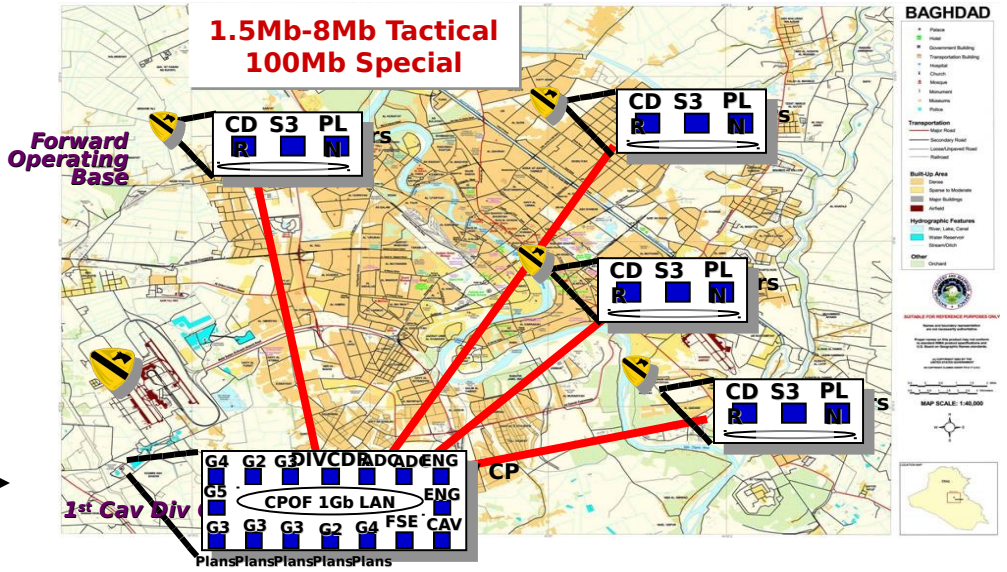


An integrated software tool suite for improved battlefield awareness and collaborative battle management

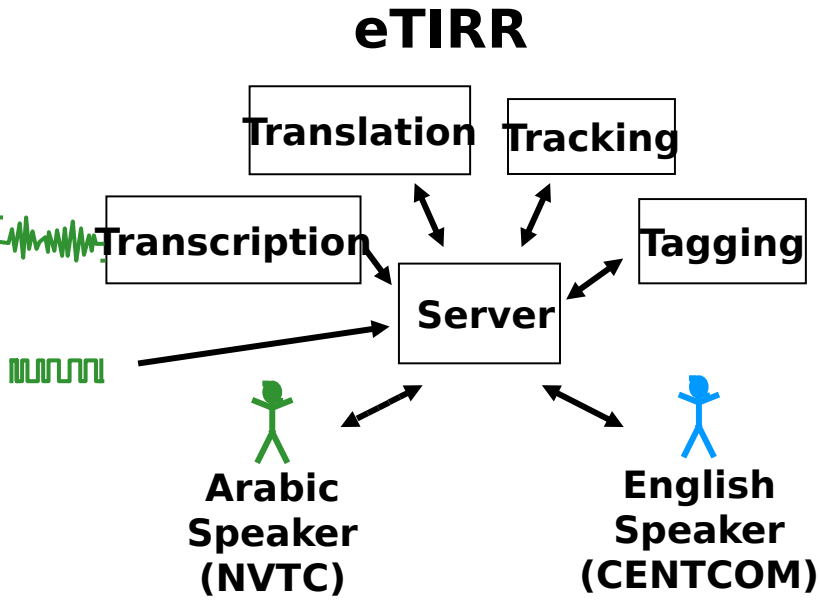
Distributed collaboration enables the elimination of place-based command posts.

Commanders and staff can be distributed across the battlefield during all phases of tactical operations

CPoF Configuration for 1st Armored Cavalry Div Baghdad



Enhanced TIDES Iraq Reconstruction Report (eTIRR)



- Exploit DARPA-funded advances in transcription, translation, tracking, tagging
- Apply to high value Arabic & English speech & text streams
- Produce timely reports of news and opinion tailored to needs of commanders in Iraq (current TIRR is used by CENTCOM, CPA)

DARPA TIDES Iraq Reconstruction Report

No. 202, 21 May 2004

In this issue:

Top Stories

- Al Qaeda suspects 'have ties with Iraq', GULF DAILY NEWS (Bahrain), 20 May 04
- Occupation bombs Iraq wedding party, AL-JAZEERA.NET (Qatar), 20 May 04
- Straw Admits That Allies' Failure To Keep Accurate Record of Civilian Deaths is 'Odd', The INDEPENDENT (London), 19 May 04
- The American Failure, AL-HAYAH (London), in Arabic, 19 May 04
- Thousands Respond to Al-Sistani's Call for Demonstrations in Karbala, VOICE OF THE MUJAHIDIN (Clandestine), in Arabic, 1400 GMT, 19 May 04
- US raids ally's Baghdad offices, AL-JAZEERA.NET (Qatar), 20 May 04
- Why the neo-cons lost their pin-up boy, ASIA TIMES ONLINE (Hong Kong), 21 May 04
- 'Zarqawi group' claims killing of council head, JORDAN TIMES (Amman), 20 May 04
  - COMMUNIQUE No. (6) ISSUED BY ZARQAWI'S "ATTAWHID AND JIHAD GROUP" - MILITARY DEPARTMENT, MAY 17, 2004 [From the SITE Institute]

Enhanced Combat Training

Two Distinct Projects

"DARWARS"

New class of PC-based cognitive learning, available anytime, anywhere

- **Squad level, multi-player, PC game providing cognitive experience of convoy ambush**
- **Easily modified scenarios and after action review capability**

Deployed to 1st Brigade, 25th Infantry Division Stryker Combat Team

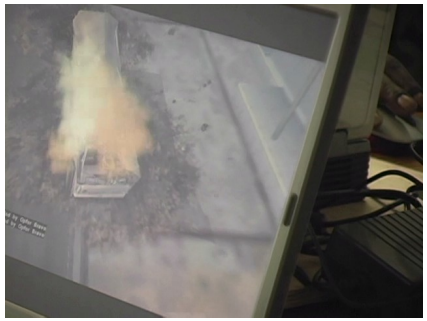
"It is as real as you can get without being in danger. I was in an ambush last year and I can see how this will help with training."

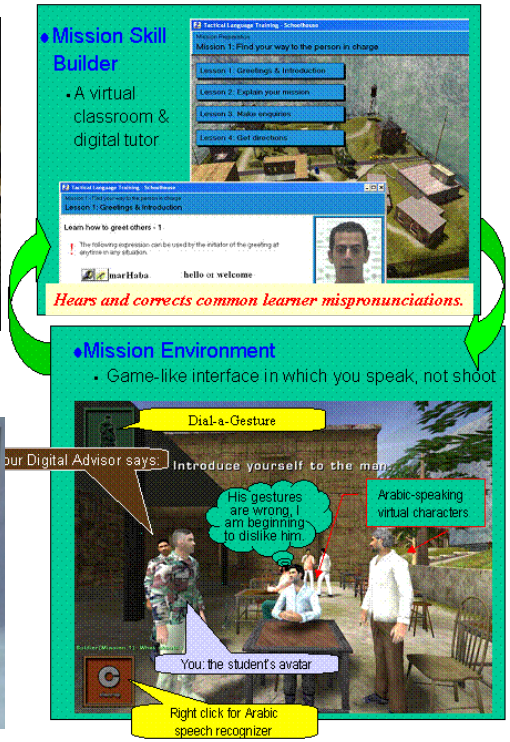
Rapid Tactical Language Training

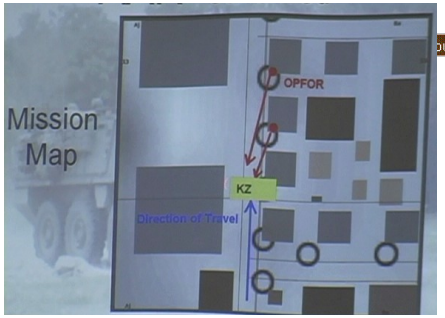
Tactical subset of language - gestures, culture, & survival vocabulary - for the soldier

"I learned more with this in one day than I did in an entire deployment in Iraq."

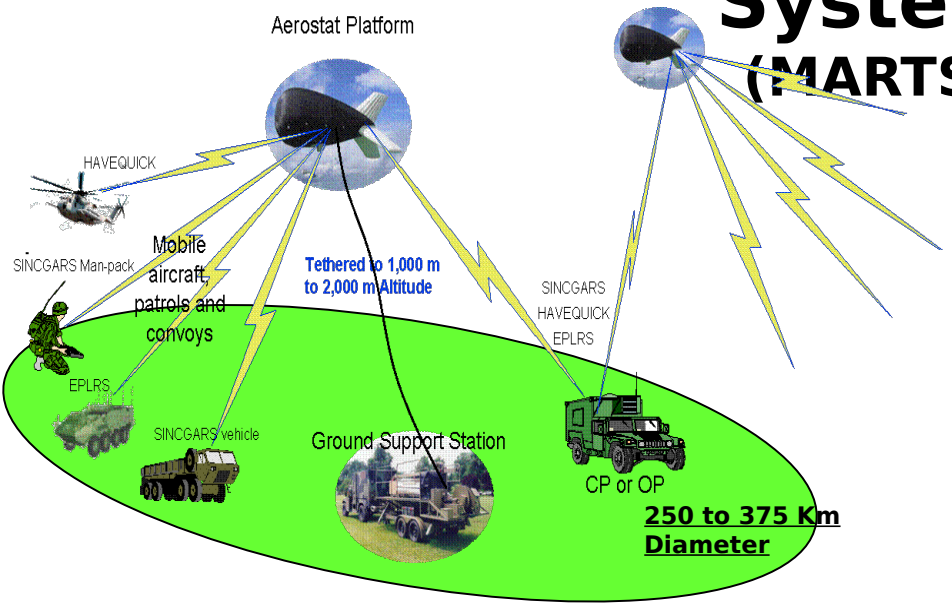
Deployed to 3rd Cavalry Regiment




♦Mission Skill Builder
• A virtual classroom & digital tutor
Hears and corrects common learner mispronunciations.
♦Mission Environment
• Game-like interface in which you speak, not shoot
Dial-a-Gesture
Introduce yourself to the man.
His gestures are wrong, I am beginning to dislike him.
Arabic-speaking virtual characters
You: the student's avatar
Right click for Arabic speech recognizer



Marine Airborne Re-Transmission System (MARTS)



Conceptual Layout

AN/PRC-117F
HAVEQUICK I/II
SINCGARS

AN/PSQ-2
EPLRS

Science Applications International Corporation
An Employee-Owned Company

NAVAIR

Aerostat Communications Relay connecting USMC SINCGARS, HAVEQUICK and ELPRS networks

Current Status

- 63K cu-Ft Aerostat GFEed to SAIC by NAVAIR late November 2004 (~400 lb+ payload)
- Upgraded Communications Payload and Ground Station to be integrated onto Aerostat during December 2004
- Training and Final Checkout schedule for January 15-31 before transfer to USMC for deployment to Iraq

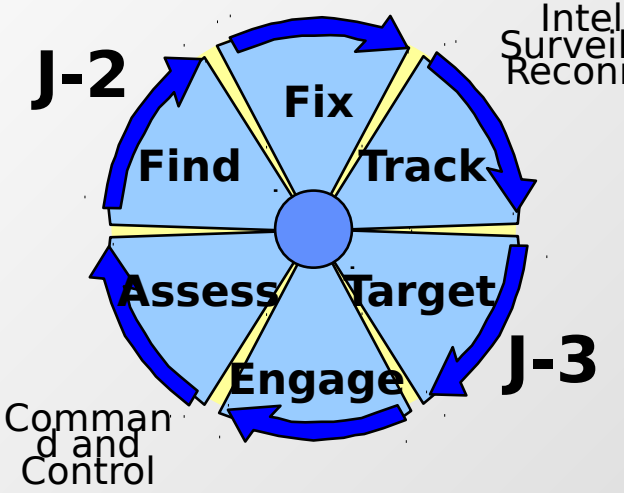
DARPA's Strategic Thrusts

Investments Today for Future Capabilities

- **Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets**
- **Location and Characterization of Underground Structures**
- **Force Multipliers for Urban Area Operations**
- **Networked Manned & Unmanned Systems**
- **Robust, Secure Self-Forming Tactical Networks**
- **Cognitive Systems**
- **Assured Use of Space**

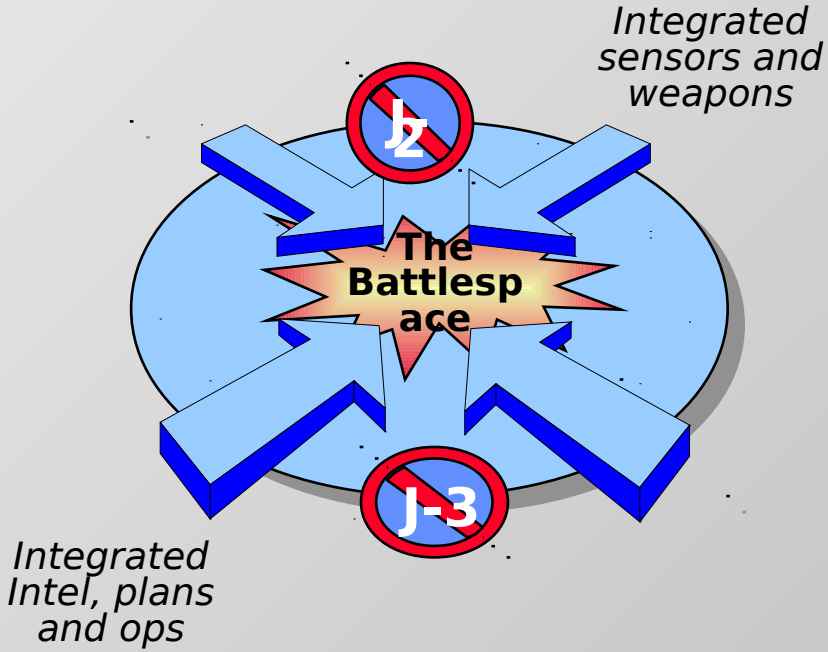
Technology Enabled C4KISR: Paradigm Shift

Current Paradigm



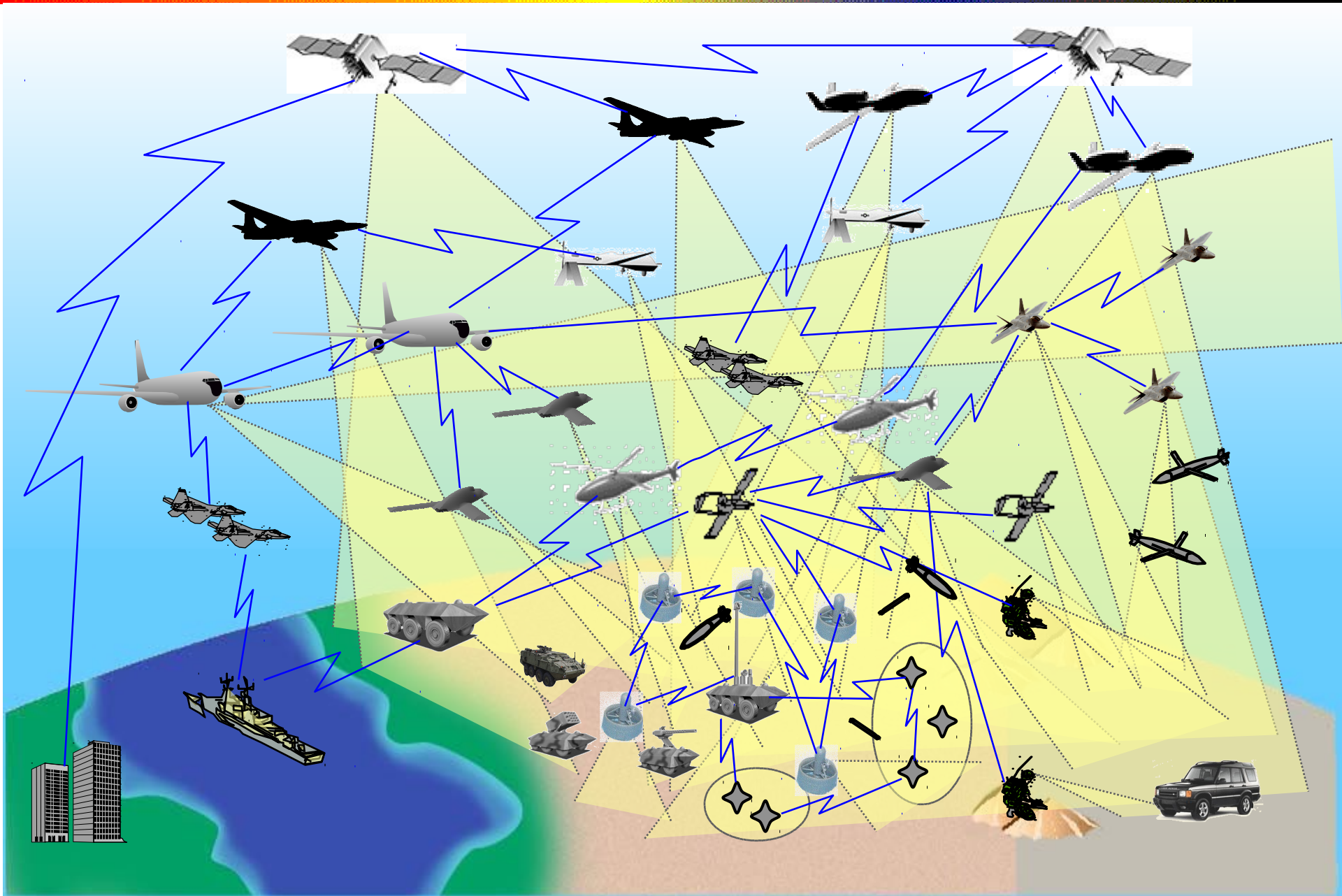
Sequential
Disjoint
Static
Rigid

New Paradigm



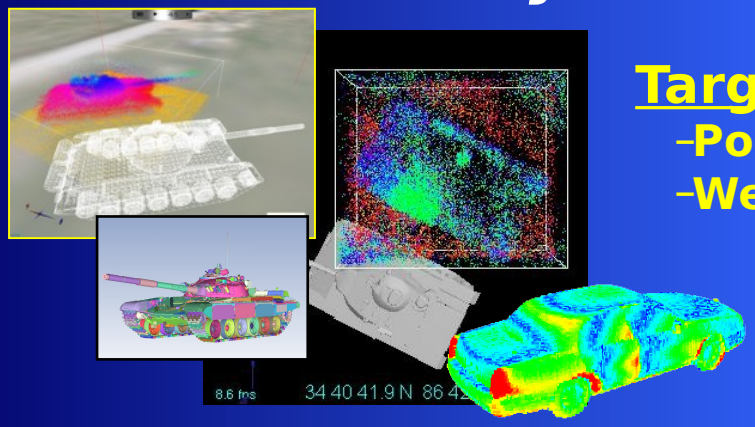
Uninterrupted
Continuous
Dynamic
Adaptive

Networked Operations



Information eXploitation Office

Key IXO Mission Thrusts

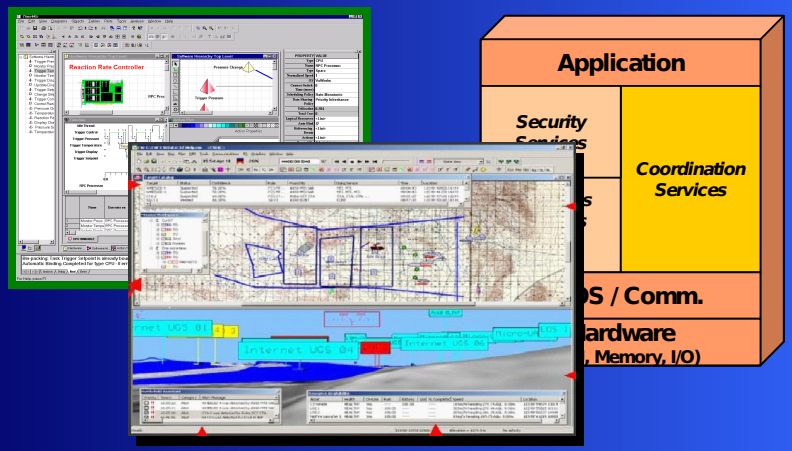


Target Understanding

- Positive Combat ID
- Weapons Effectiveness Assessment

Situation Awareness

- Complex Environments
- Real Time
- All Levels of Command



System Management

- Command and Control
- Federated Systems
- New Paradigms

Advanced Technology Office

Enabling Mobile Network-Centric Warfare

Robust, Self-Forming, Self-Defending Tactical Networks

Assured connectivity, including spectrum access, in all

Immediate network set-up and inherent flexibility to adjust as nodes enter and exit the network -- far fewer comms

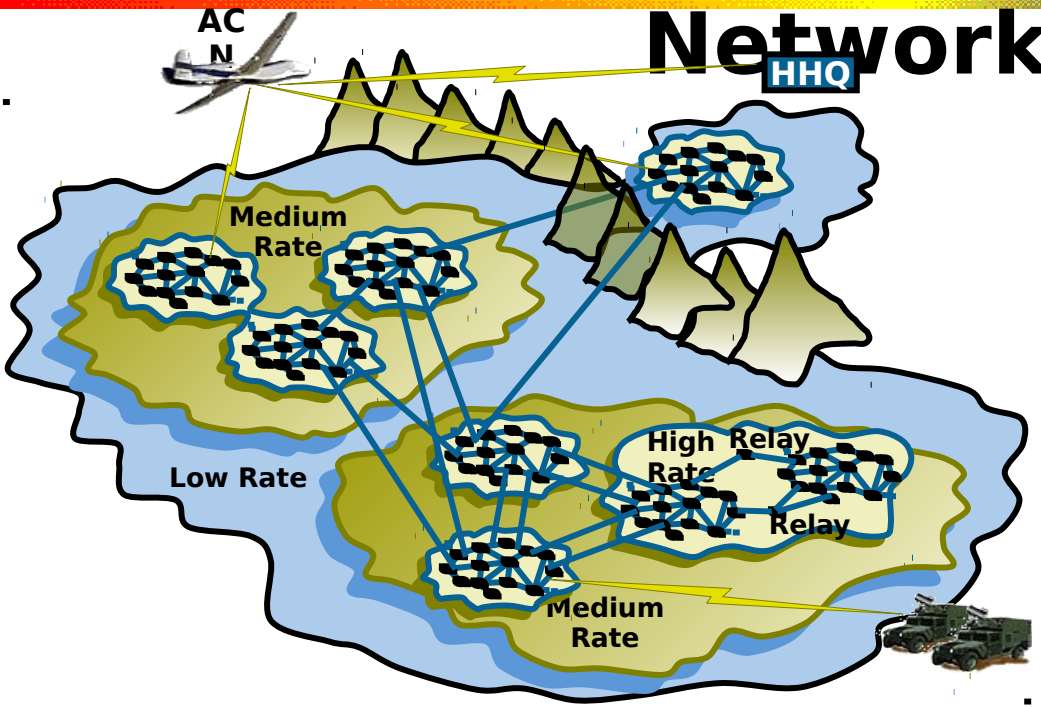
Networks continue to function through attacks by hackers, viruses, electronic jammers, or physical

DARPA's Strategic Thrusts

Investments Today for Future Capabilities

- Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets
- Location and Characterization of Underground Structures
- Force Multipliers for Urban Area Operations
- Networked Manned & Unmanned Systems
- **Robust, Secure Self-Forming Tactical Networks**
- Cognitive Systems
- Assured Use of Space

Robust, Secure Self-Forming Network



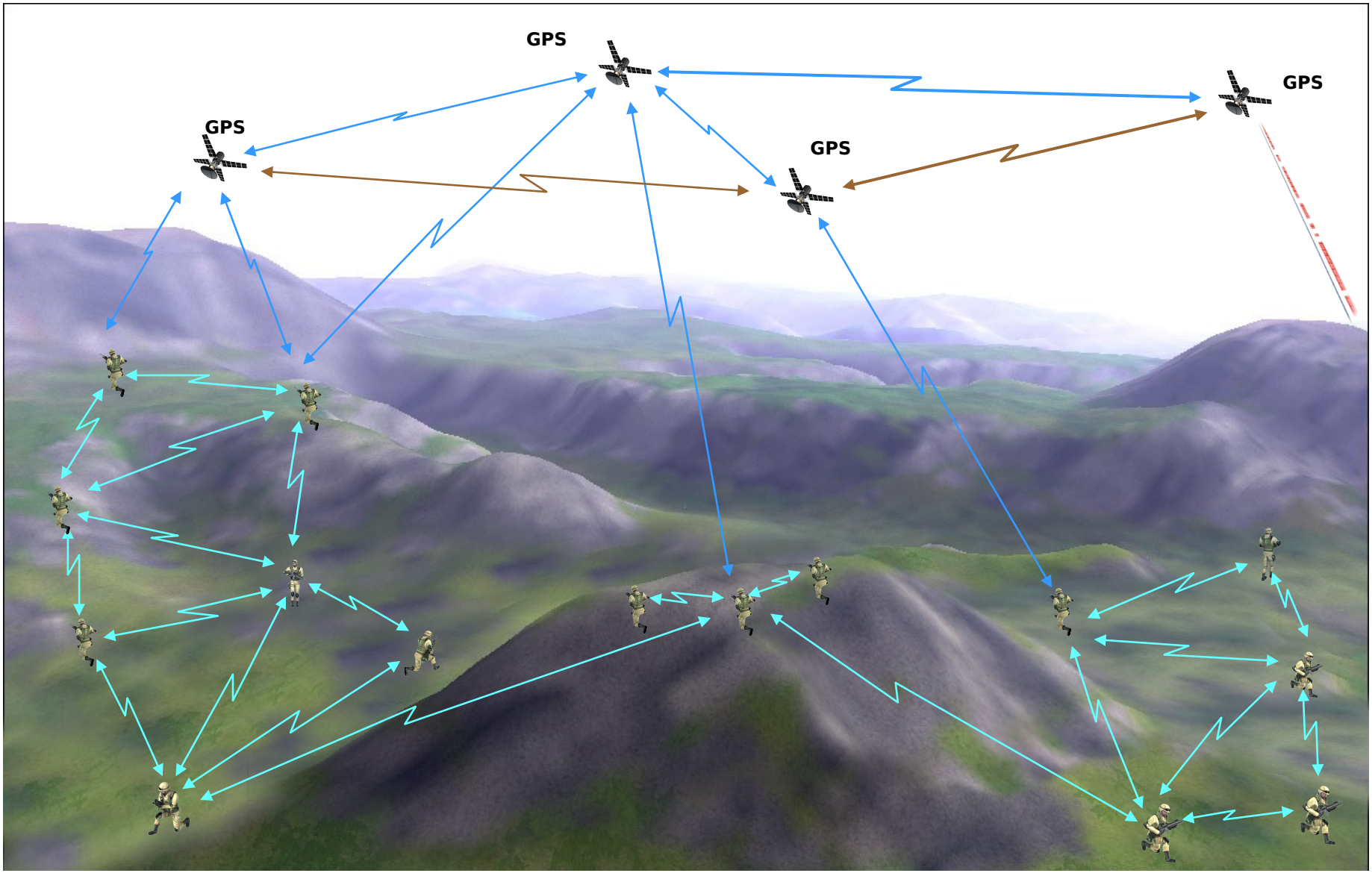
Unparalleled Communications

- Connectivity guaranteed in any environment, at distances and data rates never before available
- Minimum or no fixed infrastructure

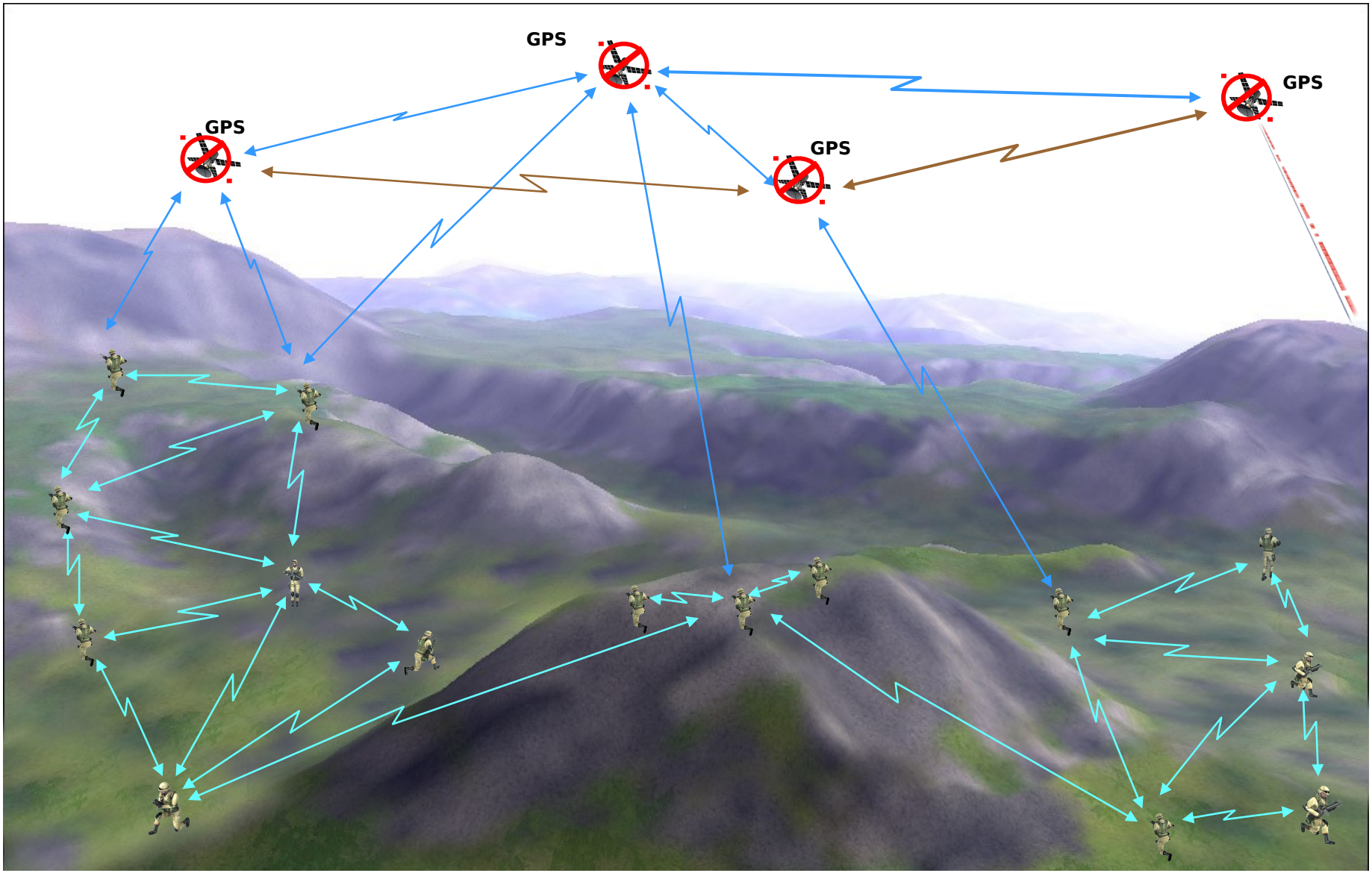
Assured Networking

- Building trustworthy systems from the ground up
- Networks to be intelligent, self-sensing & self-healing to detect and respond to attacks in real-time

Networks – GPS Reliance



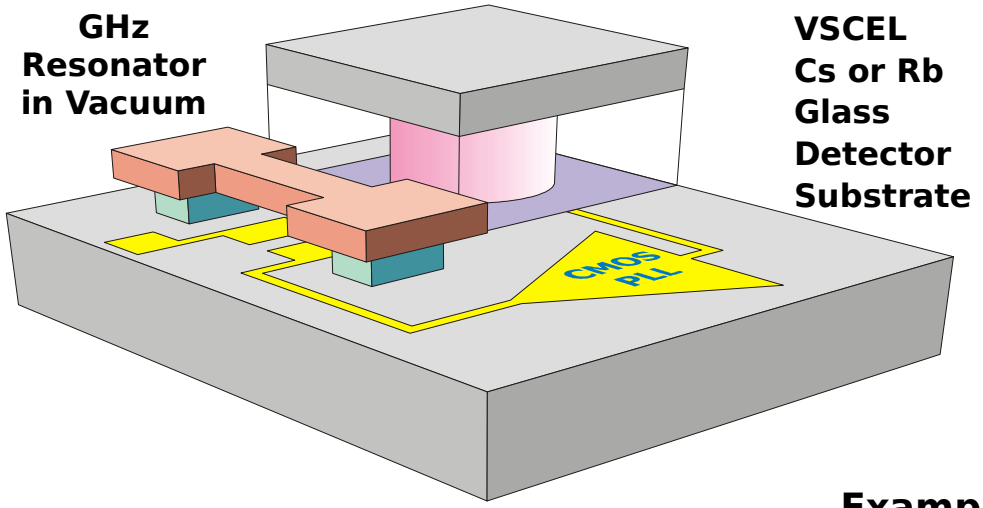
Self Forming Network – GPS



Nanotechnology for Networks

Chip-Scale Atomic Clock

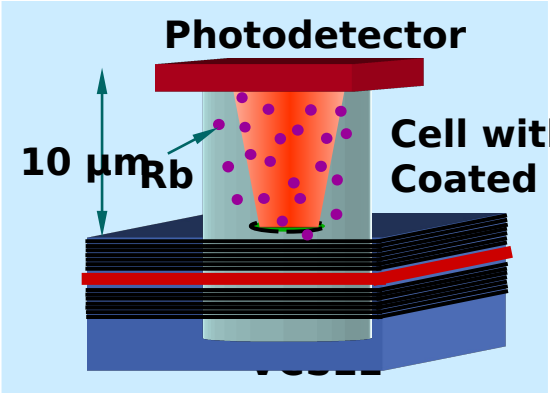
Ultra-miniaturized, low-power, atomic time and frequency reference units



>200X reduction in size

>300X reduction in power

(±1×10^{-11} accuracy ⇒ <1μs/day)



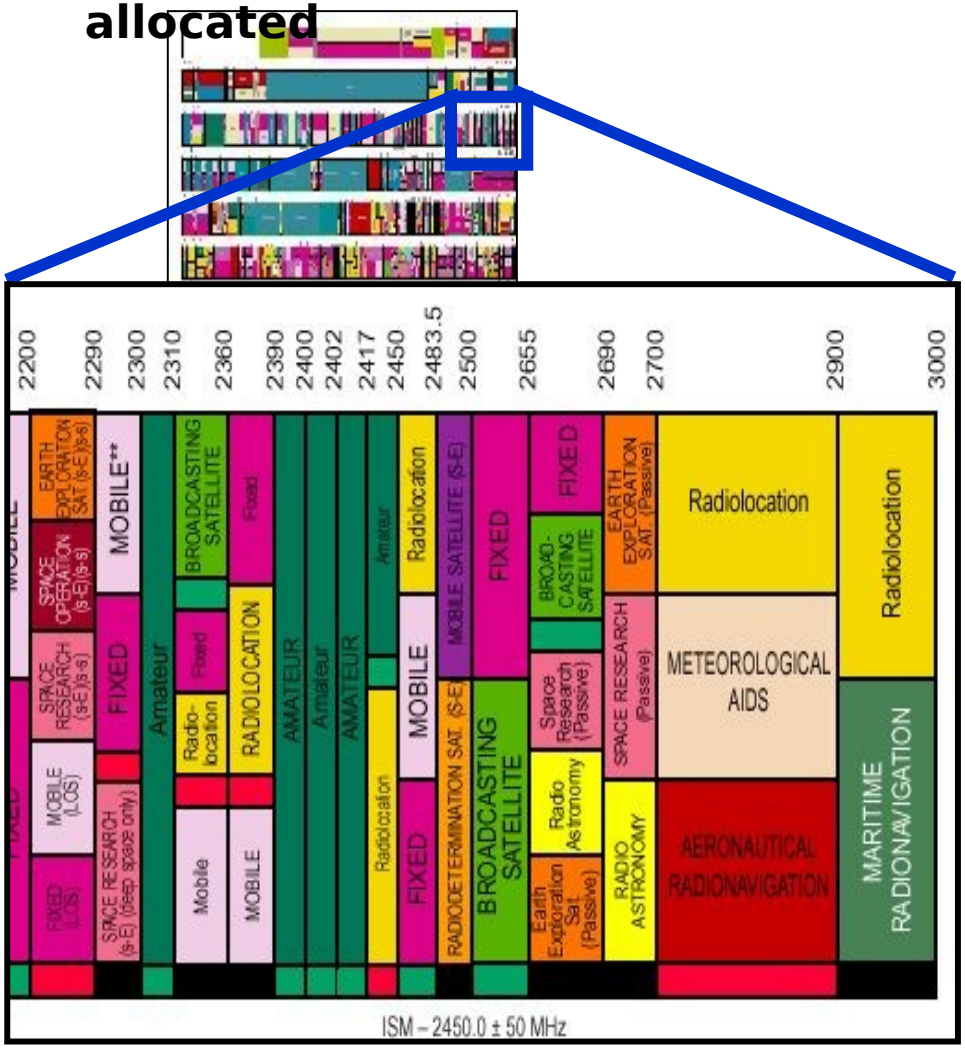
Atomic Absorption Cell

Example of Use: Radio System (SINCGARS)

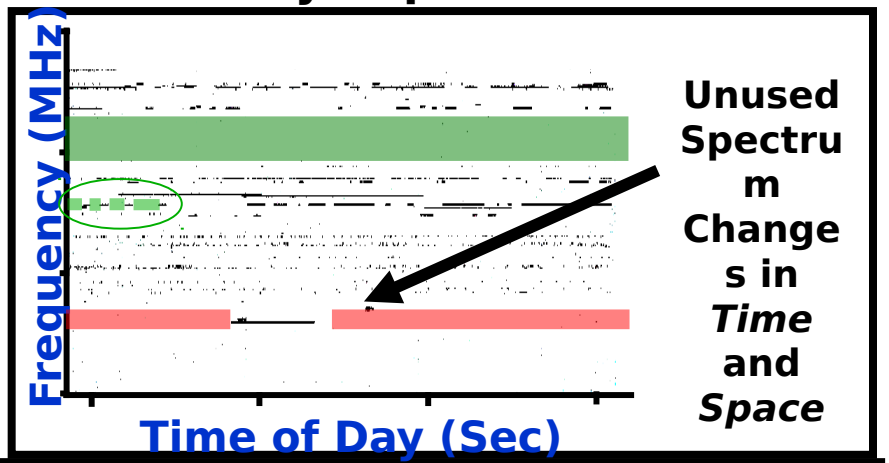
Clock accuracy of 1 × 10^{-11} ⇒ 16-hour resynch interval or radio silence

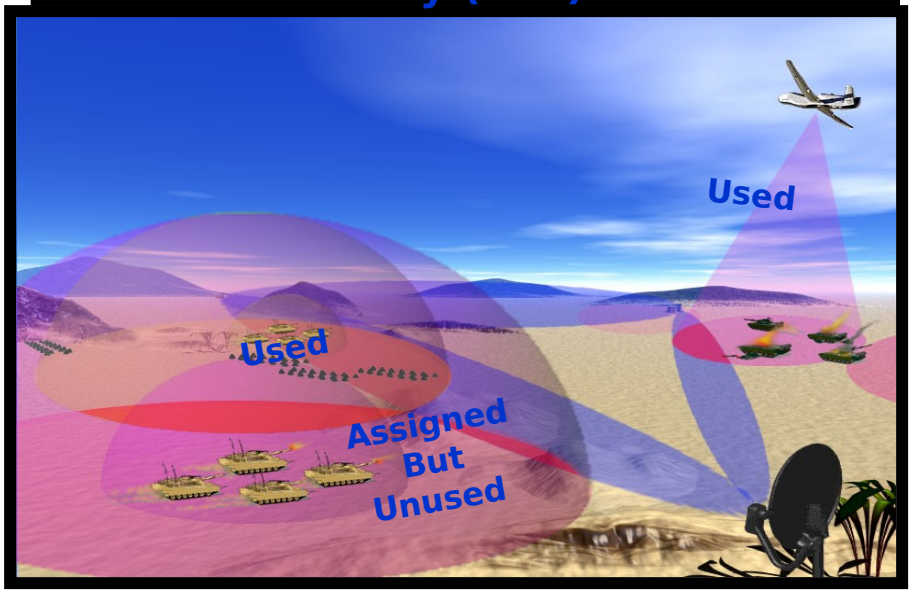
neXt Generation (XG) Communication

TODAY: **Spectrum statically allocated**



FUTURE : **Dynamically allocating spectrum in frequency, space, and time may improve utilization**





Nanotechnology

Nano-Mechanical Array Signal Processing

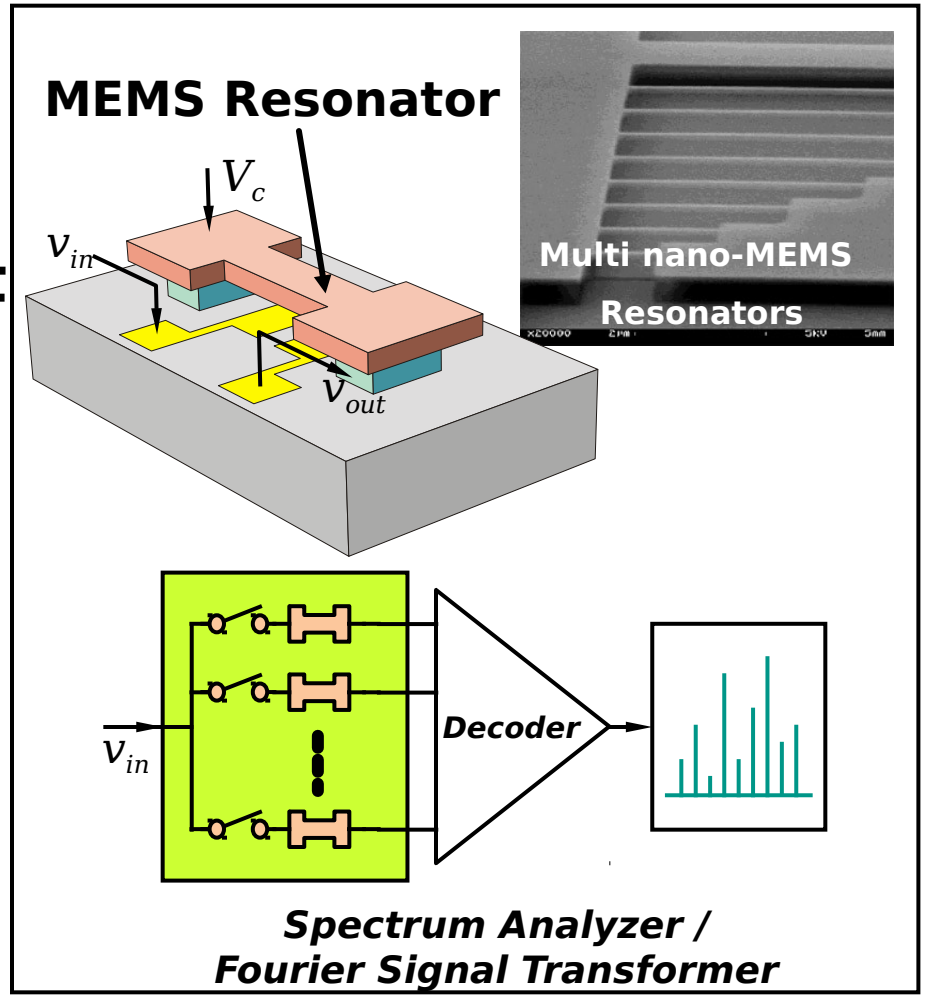
Create arrays of precision, nano MEMS structures for

RF-signal processing that achieve:

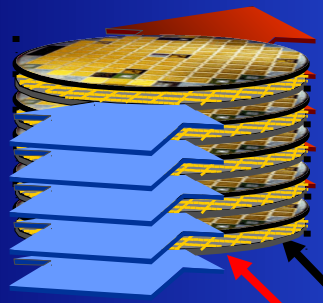
>100X reduction in size

>100X reduction in power consumption (300 mW to <3 mW)

>10X improvement in RF performance (spectral

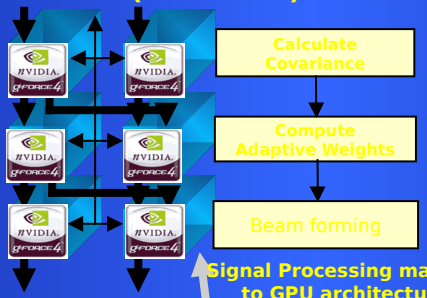


Microsystems Technology Office

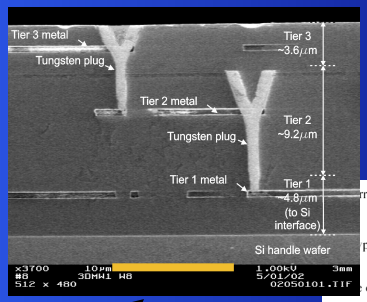


3D Integrated Circuits

Vector Processor STAP (STAP-BOY)

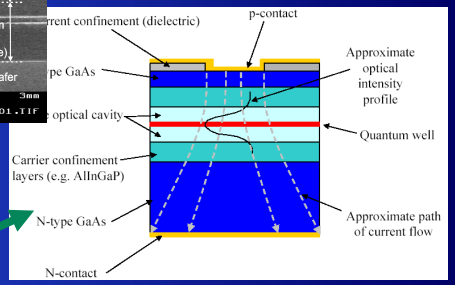


Signal Processing mapped to GPU architecture

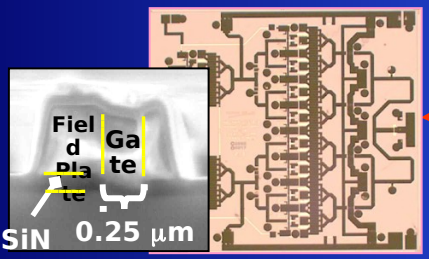


Vertically Integrated Sensor Array (VISA)

TFAST HBT cross-section

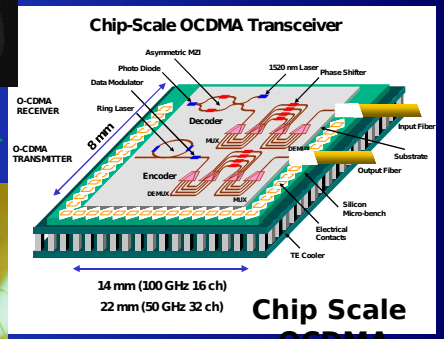


>70% Efficiency Laser Diode (SHEDS)

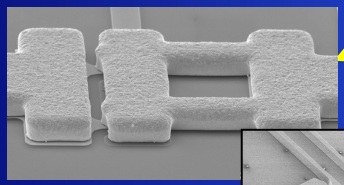


GaN High Frequency Transistor (WBG-RF)

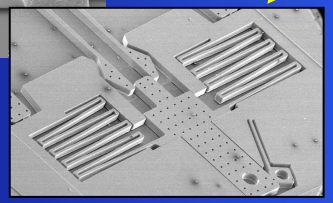
UV Laser and LED (SUVOS)



Chip Scale OCDMA



MEMS RF switch (RF MEMS Improvement RFMIP)



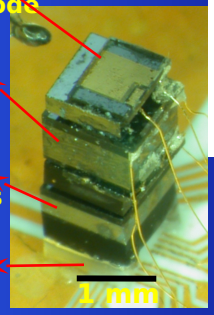
MEMS Safe-and-Arming Device (MEMS Exchange)

Photodiode

Cell

Optics

Laser



Chip Scale Atomic Clock

Algorithms

Architecture

Electronics

Photonics

MEMS/NEMS

DARPA's Strategic Thrusts

Investments Today for Future Capabilities

- Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets
- Location and Characterization of Underground Structures
- Force Multipliers for Urban Area Operations
- **Networked Manned & Unmanned Systems**
- Robust, Secure Self-Forming Tactical Networks
- Cognitive Systems
- Assured Use of Space

Unmanned Platforms

Past Successes Lead to Significantly More Complex Systems

EMPHASIS ON PERFORMANCE

EMPHASIS ON AFFORDABILITY

EMPHASIS ON MISSION EFFECTIVENESS & AFFORDABILITY

Level of Autonomy

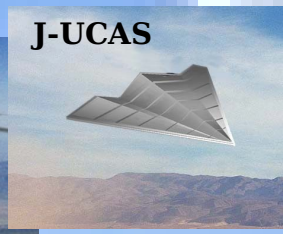
mid 80's

late80's

mid 90's

2000

2001



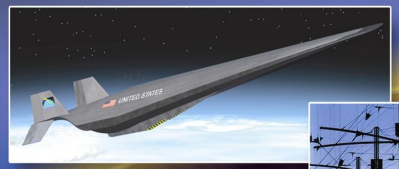
2003

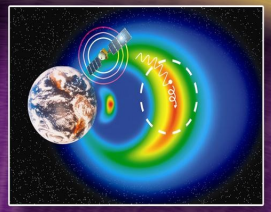
70's

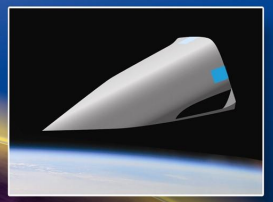
Tactical Technology Office

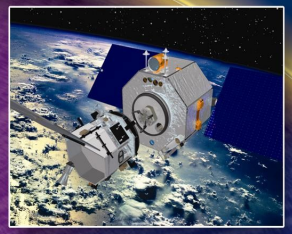
DARPA

TTO
Tactical Technology Office









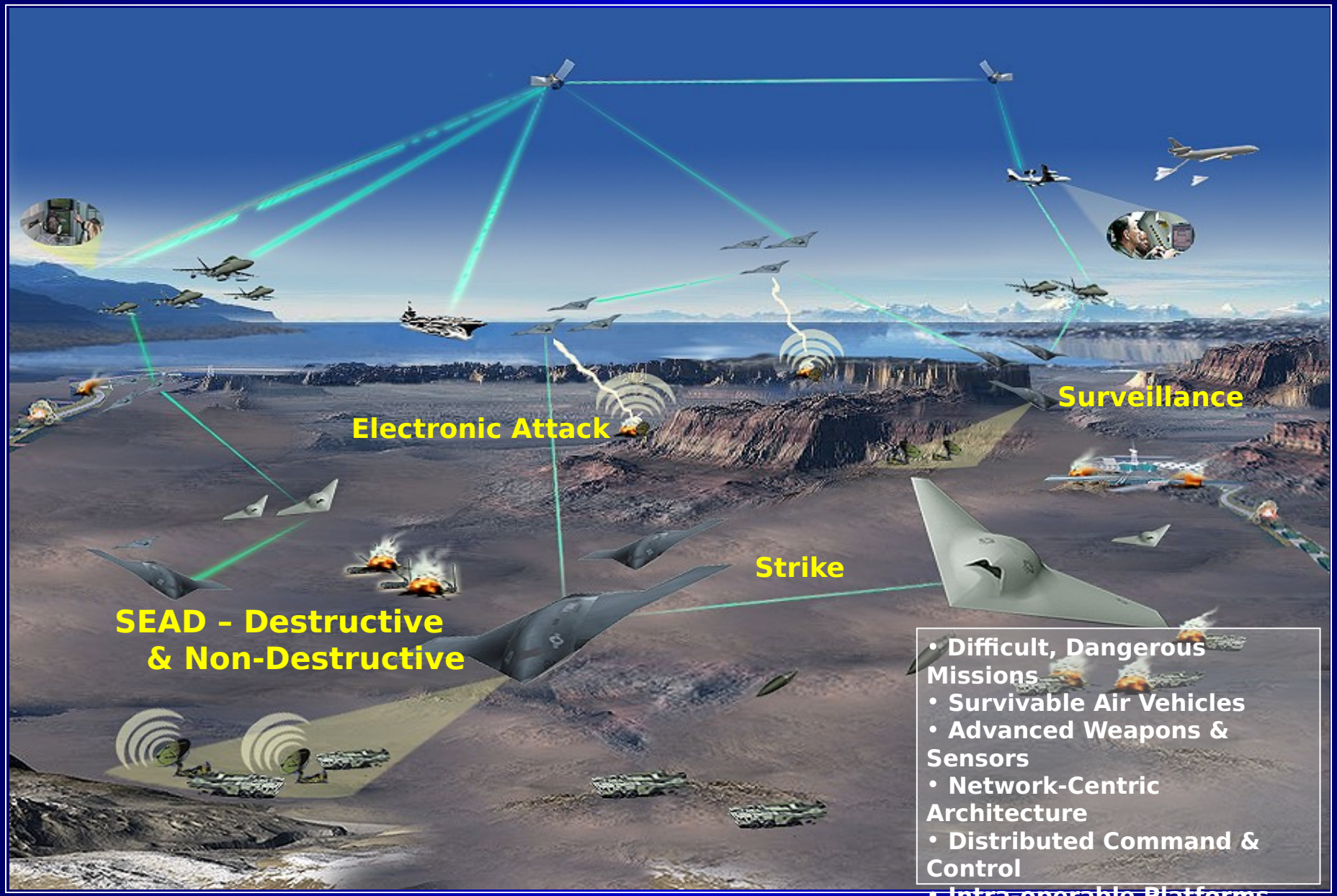
Space Systems

Tactical Multipliers

Unmanned Systems

Approved for Public Release

Joint-Unmanned Combat Air Systems Office



- Difficult, Dangerous Missions
- Survivable Air Vehicles
- Advanced Weapons & Sensors
- Network-Centric Architecture
- Distributed Command & Control
- Intra-operable Platforms

DARPA Organization

Director, Tony Tether
Deputy Director, Bob Leheny

Information Exploitation
Ted Bially
Bob Tenney/Bob Popp

- **Sensors**
- **Exploitation Systems**
- **Command & Control**

Tactical Technology
Art Morrish
Gary Graham/Stephen Welby

- **Air/Space/Land Platforms**
- **Unmanned Systems**
- **Space Operations**
- **Laser Systems**
- **Future Combat Systems**
- **Planning / Logistics**

Special Projects
Amy Alving
Joe Guerci

- **Chem/Bio Def Systems**
- **Counter Underground Facilities**
- **Space Sensors/Structures**
- **Navigation/Sensors/ Signal Processing**

Advanced Technology
Dave Honey
Larry Stotts

- **Assured C3ISR**
- **Maritime**
- **Early Entry/Special Forces**

Joint Unmanned Combat Air Systems
Mike Francis

- **Common Systems & Technologies**
- **X-45 System**
- **X-47 System**

Defense Sciences
Steven Wax
Brett Giroir

- **Bio Warfare Defense Technologies**
- **Biology**
- **Materials & Devices**
- **Mathematics**

Information Processing Technology
Ron Brachman
Barbara Yoon

- **Cognitive Systems**
- **Computational - Perception**
- **Representation & Reasoning**
- **Learning**
- **Natural Communication**

MicrosystemsTechnology
John Zolper
Dean Collins

- **Electronics**
- **Optoelectronics**
- **MEMS**
- **Combined Microsystems**

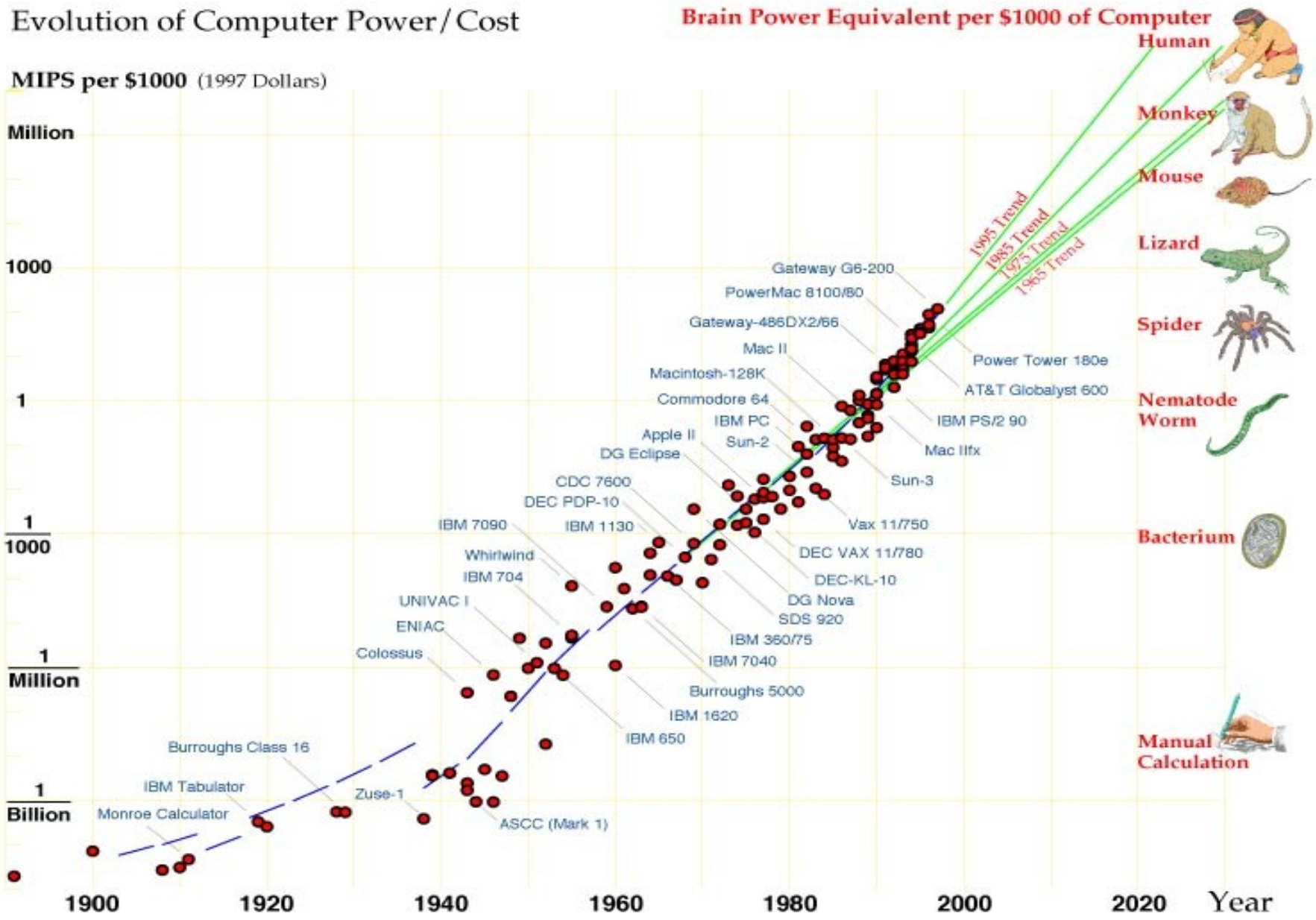
J-UCAS Transitioning to Air Force FY06

DARPA's Strategic Thrusts

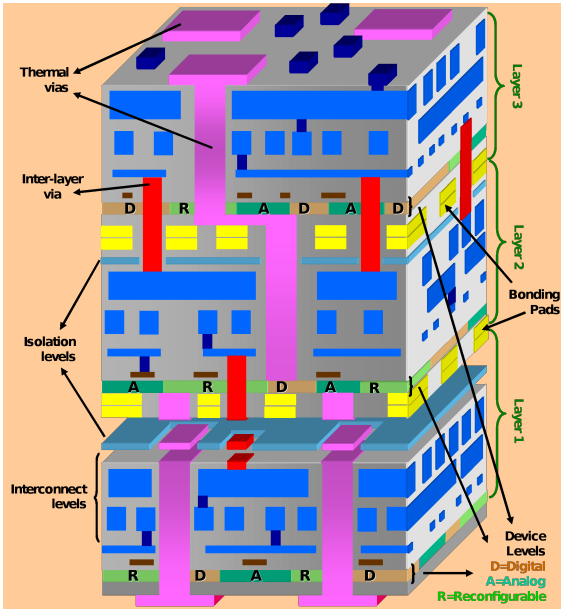
Investments Today for Future Capabilities

- Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets
- Location and Characterization of Underground Structures
- Force Multipliers for Urban Area Operations
- Networked Manned & Unmanned Systems
- Robust, Secure Self-Forming Tactical Networks
- **Cognitive Systems**
- Assured Use of Space

The Extension to Intelligent Systems



Design Tools for Integrated 3-Dimensional Electronic Circuits



DESCRIPTION / OBJECTIVES / METHODS

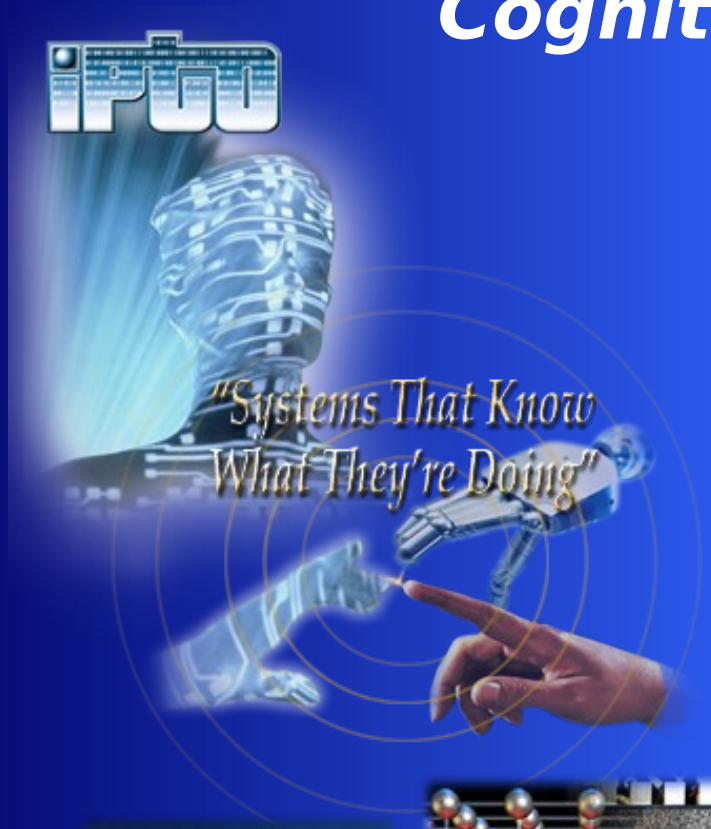
- 3-D integration significantly improves circuit performance by reducing interconnect lengths and critical delays as device sizes continue to shrink and integration densities and chip areas continue to increase.
- Novel 3D layout/routing tools, placement technologies and coupled thermal/electrical analysis tools to enable automated design of 3D circuits

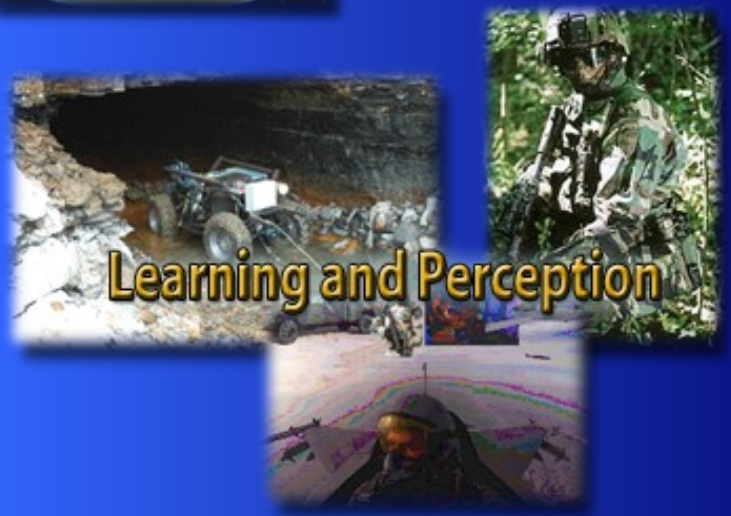
MILITARY IMPACT / SPONSORSHIP

- 3D integration has the potential to produce high performance, military relevant digital and mixed signal circuits while optimizing noise, floor area, throughput and delay.
- AFRL, EDA Community, Collaboration with other DARPA programs (NeoCAD, IRFFE, TEAM and 3D-IC).

Information Processing Technology Office

Cognitive Systems





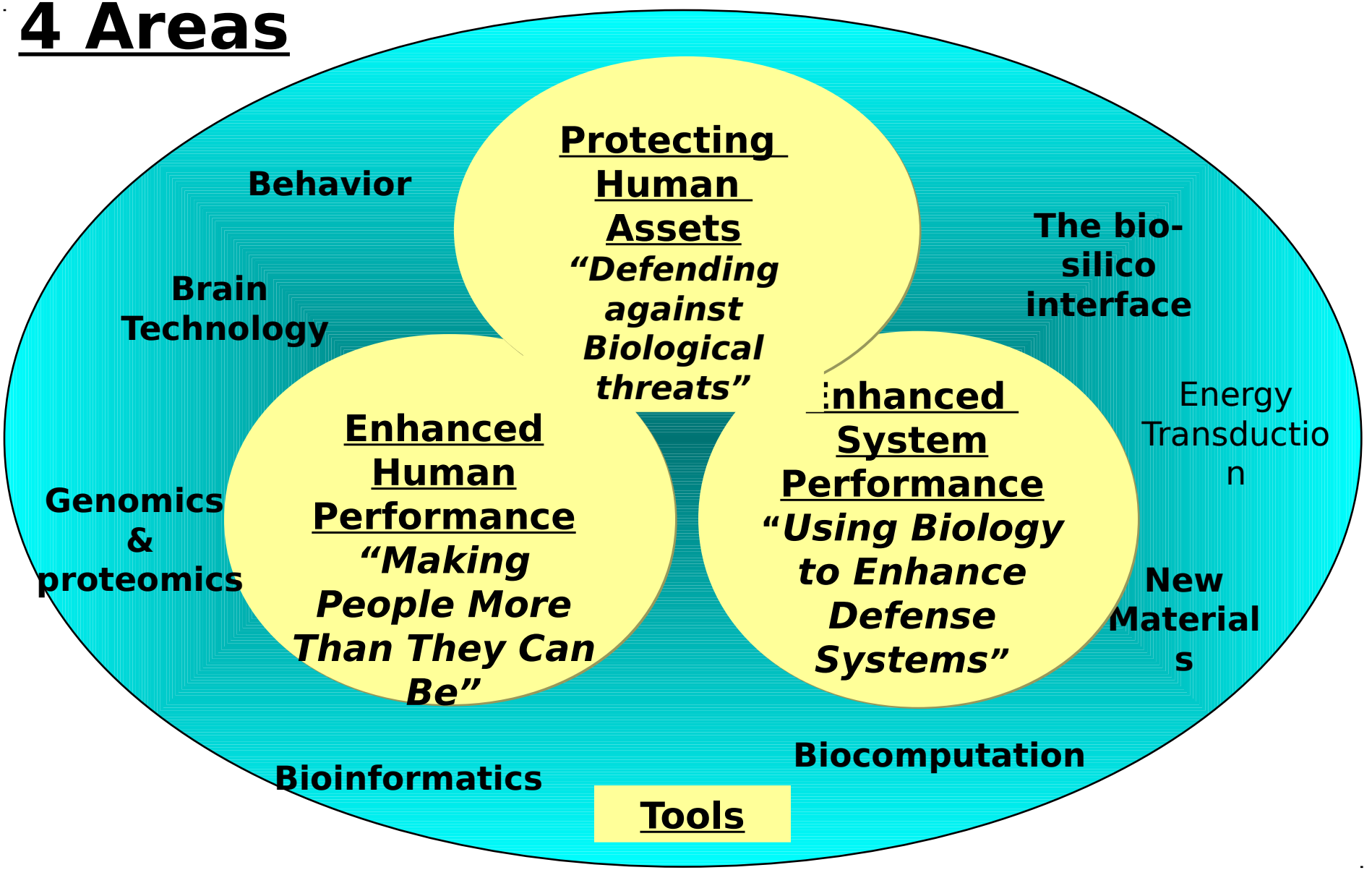
DARPA's Strategic Thrusts

Investments Today for Future Capabilities

- Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets
- Location and Characterization of Underground Structures
- Force Multipliers for Urban Area Operations
- Networked Manned & Unmanned Systems
- Robust, Secure Self-Forming Tactical Networks
- Cognitive Systems
- Assured Use of Space

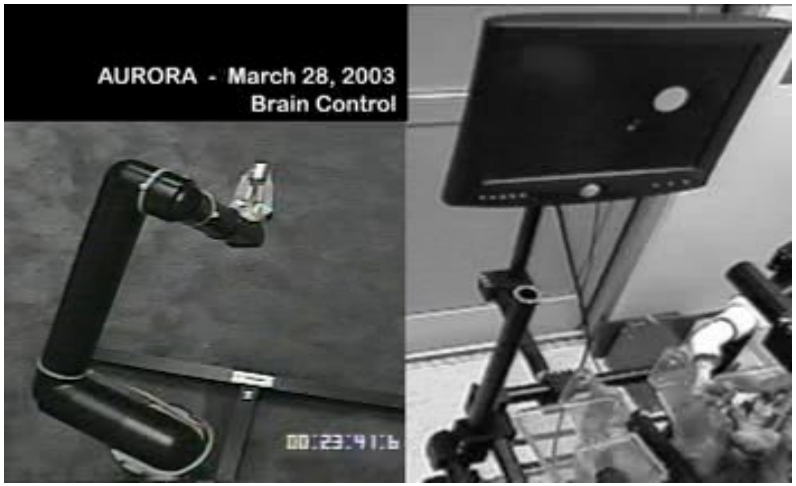
Bio Revolution

4 Areas

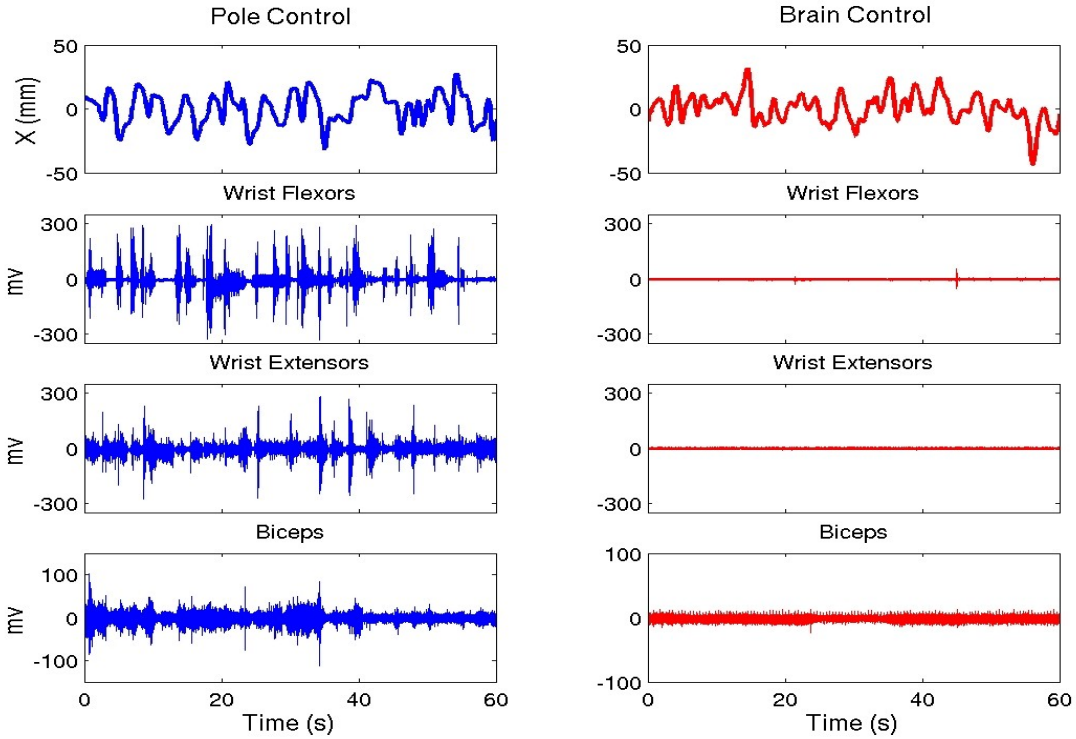


Human Assisted Neural Devices

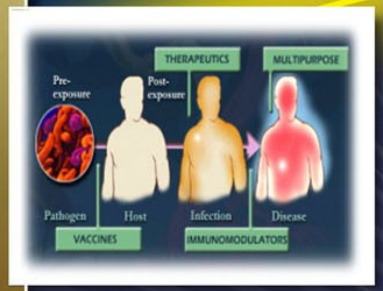
Use brain activity to command, control, actuate and communicate with the world directly through brain integration with prosthetics and peripheral devices



- Closed loop demonstration of arm reach and grasp of food
- Open loop demonstration of human control of gripping force
- Long-term compatibility
- Non-invasive correlates



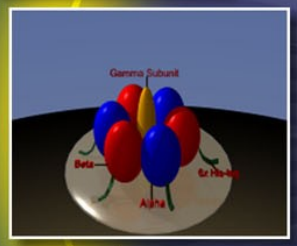
Defense Science Office

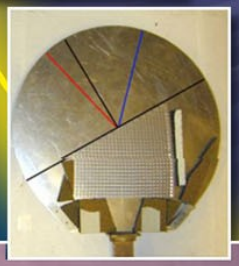


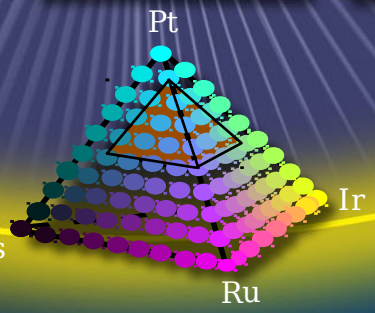
Biology

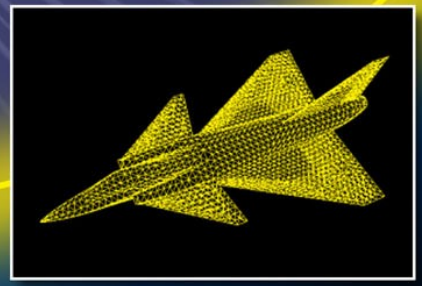
Materials & Devices

Mathematics









DARPA's Strategic Thrusts

Investments Today for Future Capabilities

- **Force Multipliers for Urban Area Operations**

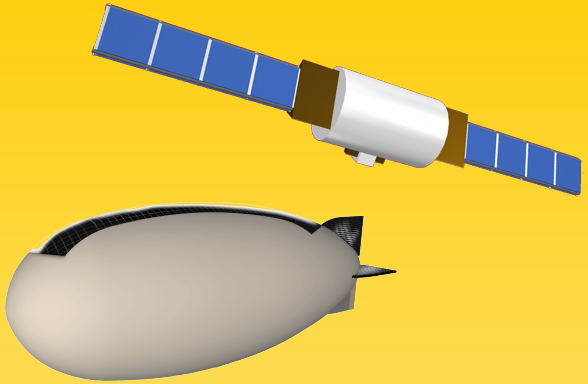
Special Projects Office

Chem/Bio/Rad

Counter Undergrounds

GPS-Free Navigation

Tailored Tactical Surveillance



Urban Operations

Virtual Space Office

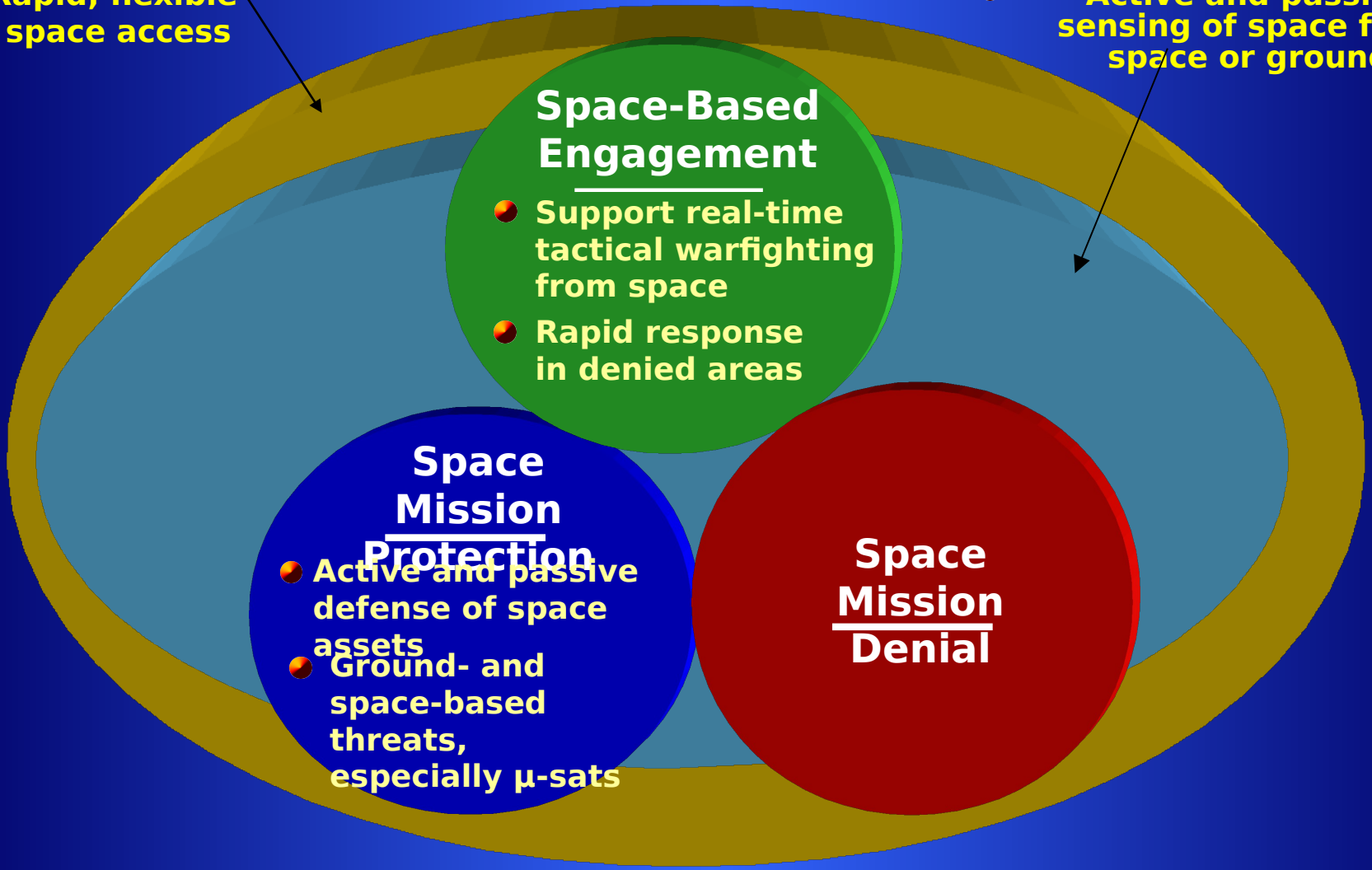
DARPA Space Projects – Five Areas

Access & Infrastructure

- Rapid, flexible space access

Situational Awareness of S

- Active and passive sensing of space from space or ground

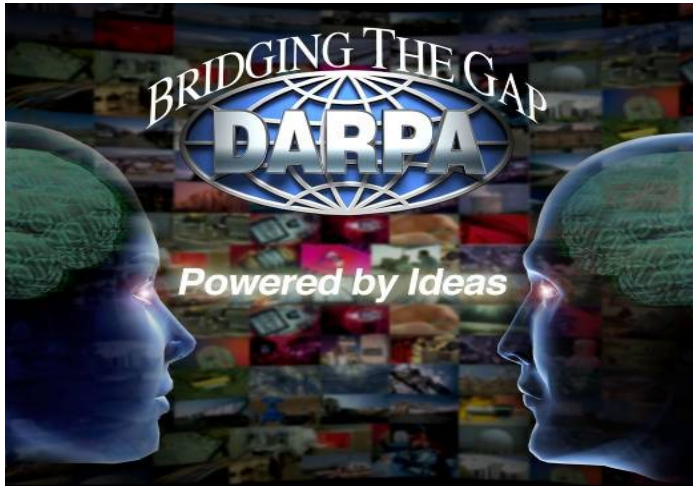

Space-Based Engagement
Support real-time tactical warfighting from space
Rapid response in denied areas
Space Mission Protection
Active and passive defense of space assets
Ground- and space-based threats, especially µ-sats
Space Mission Denial

Upcoming Key DARPA Events

DARPATech 2005
24th DARPA Systems & Technology Symposium

August 9 –August 11, 2005

Anaheim, California



GRAND CHALLENGE

National Qualification Event

September 28 – October 5, 2005

Fontana Speedway

Grand Challenge Event

October 8, 2005

Southwestern United States

SPARKING INTEREST IN SCIENCE AND TECHNOLOGY IN AMERICA
THE DARPA
GRAND CHALLENGE
BUILD A FULLY AUTONOMOUS RUGGED TERRAIN VEHICLE